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OBSERVATIONS ON OWLS, WITH PARTICULAR REGARD TO THEIR FEEDING HABITS.

THOMAS H. MONTGOMERY, JR.

THE following notes, from observations on the short-eared owl, *Asio acciptrinus* Pall., and the long-eared owl, *A. wilsonianus* Less., present some results from the examination of a considerable number of food pellets of these birds. These data may prove of interest from three points of view: (1) the kind of food eaten by these owls; (2) the relation of the amount of food found in the pellets beneath a roosting place to the total amount of food consumed; and (3) the comparative numerical abundance of small mammals in the vicinity, as deduced from their remains in the pellets.

At Christmas, 1898, four long-eared owls were found roosting in an arbor vitæ tree on my father's place, "Ardrossan," near West Chester, Penn. Before coming to this tree they had roosted in a small outleaved beech, until driven away by gunners. These owls were under my daily observation from Dec. 25, 1898, to Feb. 22, 1899. The tree on which they roosted is a large one, nearly forty feet in height, without especially dense foliage, situated between a house and a stable, about a dozen feet from either. Close to it passed many times a day people and carriages, without having the effect of frightening the birds; and they showed no concern when I collected the food pellets from the ground beneath them. In the coldest part of the winter the owls regularly faced the east, and at one time, when four roosted together, three of them roosted near the center of the tree, one near the top, and each occupied regularly a particular branch.

About thirty feet to the southeast of the house is a magnificent Norway spruce, the roosting place of a short-eared owl. I first observed this bird on February 2, and kept it under regular observation from February 26 to March 26, except for a lapse of a few days between March 8 and 14. For a part of this time one of the long-eared owls, after leaving the arbor vitæ tree, roosted in this Norway spruce also.

These two trees were the only regular roosting places of owls in the neighborhood at this time, though there were a number of evergreen trees in the vicinity which were casual feeding perches, under which I found pellets.

My observations were of the following nature: Each day the number of owls were counted on the two roosts, and at regular intervals (usually each Sunday) all pellets were collected from the ground beneath each roost. These pellets were carefully examined, the number and kind of animal remains in them noted, and so the daily food average per owl computed. Here I wish to thank my friend Mr. Witmer Stone, curator at the Philadelphia Academy of Natural Sciences, for his assistance in determining the species of mammals.

First, a few notes as to the construction of the food pellets. It is well known that owls, as a rule, swallow their prey whole, that the food remains in the stomach until all digestible substances are extracted and passed into the small intestine, and that finally the remaining mass of undigested substances (bones with hair or feathers, hard parts of insects, etc.) is disgorged as a pellet (bolus). The pellets are more or less ovoid in form, and when freshly disgorged covered with a slimy mucus. Each pellet, of the two species of owls studied, usually contains the remains of only one food individual (*i.e.*, one mouse or one bird); about one in twenty contains two individuals; rarely are more than two present in the same pellet, and pellets of this nature are considerably longer than usual, though of the ordinary diameter. The pellet, when the object eaten is a mammal or bird, is composed of a tightly welded mass of bones and hairs, or feathers. In the stomach of the owl the food mass must be subjected to a vigorous churning process, for only such a process could serve to explain the close welding of the materials in the ejected pellet. In a pellet there are no empty spaces, but the hairs or feathers fill tightly all the spaces between the bones, and are jammed into all grooves and foramina of the latter, the pellet, when fresh, being so compact that it cannot be roughly torn apart without breaking the bones contained in it. The skulls of mice are usually found crushed in the occipital region (the weakest portion), usually more or less intact anterior to the frontal; out of 570 skulls of the meadow mouse taken by me from pellets, only some fifty had the occipital region uninjured and attached to the rest of the skull; when several mice are contained in the same pellet, the state of preservation of the skulls is better than usual. It is truly remarkable how the hair is worked, by the churning process of the owl's stomach, into all cavities of the skull. There is always a tight wedge of hair in the preorbital foramen, in the foramen lacerum, in the ear and nasal cavities, as well as in smaller apertures. When the occipital region of the skull is crushed, the cranial cavity contains a tight wad of hair; and in a few skulls which remained intact the whole cranial cavity was densely packed with hair which had been forced through the foramen magnum! The lower jaws are usually well preserved (though their angular and coronary processes are frequently broken), and teeth are well preserved. Of the other bones of the mouse's skeleton contained in a pellet, it is strange that the slender and delicate ulnæ and radii are usually intact; the proximal end of the humerus is usually dislocated; the femora, tibiæ, ilia, vertebræ, and small bones of the hand and foot are usually uninjured, while the ribs, scapulæ, and fibulæ are usually broken. The less strongly built skulls of shrews and birds are considerably more crushed. As MacGillivray noted in 1836, the linings of birds' gizzards are disgorged intact in the pellets. As far as I can determine, the gastric juices of the owls have no noticeable action upon bones.[1]

I.

The following tables represent the food eaten by the owls under my observation. Table I is for the long-eared owls on the arbor vitæ tree; Table II for the long-eared and the short-eared owl on the Norway spruce. For each table the first

TABLE I. ARBOR VITÆ TREE.

DATE OF COLLECTION	NUMBER OF OWLS ON THE TREE		CONTENTS OF PELLETS	DAILY FOOD AVERAGE
Jan. 8	Dec. 25,	4	1 Finch 1 Blarina 1 *Micr. pinet.* 139 *Micr. penn.* 14 *Micr. undet.*	
	" 26,	4		
	" 27,	4		
	" 28,	4		
	" 29,	4		
	" 30,	4		
	" 31,	4		
	Jan. 1,	4		
	" 2,	4		
	" 3,	4		
	" 4,	4		
	" 5,	4		
	" 6,	4		
	" 7,	4		
	" 8,	4		
Jan. 15	Jan. 9,	4	1 Peromyscus 1 *Micr. pinet.* 43 *Micr. penn.*	1.6
	" 10,	4		
	" 11,	4		
	" 12,	4		
	" 13,	4		
	" 14,	4		
	" 15,	4		

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[1] The pellets of hawks (I am familiar with those only of *Falco sparverius*) are very different from those of owls. The pellets of the sparrow hawk are smaller, elongate, usually pointed at the ends, and more or less spirally twisted. In them there is frequently no trace of bones, and when the latter are present they are usually in a fragmentary condition. A hawk tears its prey to pieces in the process of eating, which would account for the breaking of the bones.

Table I. — *Continued.*

Date of Collection	Number of Owls on the Tree		Contents of Pellets	Daily Food Average
Jan. 22	Jan. 16,	4	2 *Micr. pinet.* 41 *Micr. penn.* 4 *Micr. undet.*	1.57
	" 17,	4		
	" 18,	4		
	" 19,	4		
	" 20,	5		
	" 21,	4		
	" 22,	5		
Jan. 29	Jan. 23,	5	1 Mus. 47 *Micr. penn.*	1.92
	" 24,	0		
	" 25,	4		
	" 26,	4		
	" 27,	4		
	" 28,	4		
	" 29,	4		
Feb. 5	Jan. 30,	4	1 *Passer domesticus* 1 *Micr. pinet.* 25 *Micr. penn.*	2.16
	" 31,	0		
	Feb. 1,	1		
	" 2,	0		
	" 3,	3		
	" 4,	2		
	" 5,	2		
Feb. 26	Feb. 6,	2	1 Peromyscus 1 *Micr. pinet.* 24 *Micr. penn.*	1.86
	" 7,	1		
	" 8,	2		
	" 9,	2		
	" 10,	1		
	" 11,	2		
	" 12,	2		
	" 13,	1		
	" 14,	0		
	" 15,	0		
	" 16,	0		
	" 17,	0		
	" 18,	0		
	" 19,	0		
	" 20,	0		
	" 21,	0		
	" 22,	1		

Table II. Norway Spruce Tree.

Date of Collection	Number of Owls on the Tree	Contents of Pellets	Daily Food Average
Feb. 26	Feb. 2, 5 *wils.*, 1 *acc.* " 3, 1 *acc.* " 19, 1 *wils.* " 24, 1 *wils.* " 26, 1 *wils.*	50 *Micr. penn.*	
Mar. 5	Feb. 27, 1 *wils.* " 28, 1 *wils.* Mar. 1, 1 *wils.* " 2, 1 *wils.* " 3, 1 *acc.* " 4, ? " 5, 1 *acc.*, 1 *wils.*	1 *Blar. parva* 1 Zapus 1 Cambarus 1 Finch (?) 27 *Micr. penn.*	2.42 ?
Mar. 14	Mar. 6, 1 *acc.*, 1 *wils.* " 7, 1 *acc.* " 8, 0 ? " 14, 1 *acc.*	1 *Passer domesticus* 1 *Melospiza fasciata* 1 *Blar. parva* 18 *Micr. penn.*	
Mar. 19	Mar. 15, 1 *acc.* " 16, 1 *acc.* " 17, 1 *acc.* " 18, 1 *acc.* " 19, 1 *acc.*	1 *Melospiza fasciata* 6 *Micr. penn.*	1.2
Mar. 26	Mar. 20, ? " 21, 1 *acc.* " 22, 1 *acc.* " 23, 1 *acc.* " 24, 1 *acc.* " 25, 1 *acc.* " 26, 1 *acc.*	1 Bird 4 *Micr. penn.*	·57

vertical column gives the date of collection of pellets; the second, the number of owls on the tree each day; the third, the contents of the pellets; the fourth, the number of small mammals (mice and shrews) eaten by each owl daily. This number was ascertained at each period of collection of pellets, by dividing the total number of mammals by the number of days when owls were present on the tree, and dividing the resultant number by the total number of owls divided by the number of days. The second vertical column of Table II shows which of the two species of owls were present each day, by the abbreviations "acc." and "wils." for *Asio acciptrinus* and *A. wilsonianus* respectively. In the third vertical column of both tables "Micr. penn." stands for *Microtus pennsylvanicus* (meadow mouse); "Micr. pinet.," for *M. pinetorum* (pine mouse); "Micr. undet.," for species of Microtus which could not be determined owing to the poor state of preservation of the remains; "Mus," for *Mus musculus* (house mouse); "Peromyscus," for *P. leucopus* (white-footed mouse); "Zapus," for *Z. hudsonius* (jumping mouse); "Blar. brev.," for *Blarina brevicauda;* and "Blar. parva," for *B. parva.*

For each owl on the arbor vitæ tree the daily average of small mammals, in the different weeks, varied from 1.57 to 2.16. The collection of pellets made on January 8 had been accumulating for an undetermined period antecedent to that date. It is interesting to note that in the especially cold and stormy month of February the amount of food obtained by the owls was up to the average. The contents of these pellets may be summarized: 2 birds, 1 Blarina, 2 *Peromyscus leucopus,* 1 *Mus musculus,* 6 *Microtus pinetorum,* 319 *M. pennsylvanicus,* and 18 undetermined individuals of Microtus.

For the owls on the Norway spruce the daily average of small mammals per owl was 1.2 one week, and only .57 another; for the week given in the second transverse column of this table it would be 2.42, provided two owls were present each day, which I have good reasons to suppose to be the case, though I did not see the two each day. I could not determine how long the pellets had been accumulating which are given in the first transverse column. To summarize the pellets of this table: 1 Cambarus, 5 birds, 2 *Blarina parva,* 1 *Zapus hudsonius,* and 105 *Microtus pennsylvanicus.* On the Norway spruce the short-eared owl was the regular resident, the long-eared owl more irregular in occurrence; and it is probably due to the differences in the feeding habits of the former that the bones in the pellets were more badly broken than is the case with long-eared owls, and that the daily food average was smaller.

Within a radius of an eighth of a mile of these two trees there are a number of evergreen trees, under which I found at various times considerable numbers of pellets; since these proved to be not roosting but merely casual feeding perches, and since I found no other owls roosting in the vicinity, it would seem very probable that these pellets, or most of them, were produced by the owls observed by me. These pellets contained the remains of 5 small birds (including Regulus, Junco, Certhia), 3 *Blarina brevicauda*, 3 *B. parva*, 1 Blarina, undetermined, 2 *Zapus hudsonius*, 3 *Peromyscus leucopus*, 1 *Microtus pinetorum*, 139 *Microtus pennsylvanicus*, and 4 undetermined individuals of Microtus. Pellets found under trees which are not day roosts would necessarily contain the remains of animals eaten by the owls in the early evening, before they returned to their roost.

II.

The very fact that pellets are found beneath trees which are merely feeding perches, as they have been termed by me, proves that the pellets beneath a roost do not represent all produced by owls. How great a proportion of all the food consumed is contained in the roost pellets cannot be determined by field observation alone, since it is impracticable to follow and observe owls during their nocturnal wanderings. To determine how much food is eaten by owls, and how many pellets are disgorged away from their roosting places, I have compared my data with those given by Dr. A. K. Fisher in his very able and thorough work, "The Hawks and Owls of the United States in their Relation to Agriculture" (*U. S. Dept. Agric. Bulletin*, No. 3, 1893). Dr. Fisher tabulates the results of the examination of several thousand stomachs of our rapacious birds. To be sure, the number of objects found in an owl's stomach do not necessarily represent all eaten by that owl in the course of a day. But since Fisher's tables show per bird a somewhat higher average of food contents than do mine on pellets, his figures would approximate closer to the total food consumption per owl, and on this account the comparison of the two sets of data may be of interest.

Fisher gives the results of examination of the contents of 92 stomachs of *Asio wilsonianus*, and of 87 stomachs of *A. acciptrinus* (when we eliminate those stomachs which were found empty, and which probably were of birds shot in the daytime). I have carefully computed from Fisher's tables for these two species of owls the exact number of food objects in detail per stomach, and the results may thus be compared with my data, counting in only mice, shrews, and small birds.

A. wilsonianus	(Fisher)	mice,	shrews,	1.52 ; birds, .26.
	(mihi)	"	"	1.57, 2.16 ; birds, .08.
A. acciptrinus	(Fisher)	"	"	1.78 ; birds, .22.
	(mihi)	"	"	.57, 1.2 ; birds, .14, .2.

This comparison of the two sets of data would show that the long-eared owl probably does the greater part of its digestion, and disgorges most of its pellets on its roost. But the short-eared owl, since here there is a marked discrepancy between the figures of Fisher and myself, would appear to disgorge a smaller proportion of its pellets at its roost, and a considerable number at casual feeding perches; this is probably referable to the more crepuscular mode of life of the short-eared owl, which leaves its roost earlier in the evening, and returns to its roost later in the morning. The food of the short-eared owl is more diversified than that of the other species, probably due to its covering more varied feeding grounds in its hunts.

III.

Finally, as to the numerical abundance of our mice and shrews, as deduced from the relative abundance of their remains in owl pellets. It must be kept in mind that owls hunt for their food mainly on open meadow and marsh land, less in thick woodland. Their hunting is also mainly done by night. Accordingly, woodland and diurnal mammals would be less frequently destroyed by them than would nocturnal mammals of the more open districts. But the following figures would give a fair comparison of the numerical abundance of such small nocturnal mammals as are found at night in the hunting areas of the long-eared and short-eared owls. To the data of contents of pellets from the Norway spruce, and arbor vitæ trees, and of feeding perches within a radius of an eighth of a mile of them, I will add the contents of pellets found at other localities in the course of this season of observation, and we find the following numbers of individuals of different species of mice and shrews: *Microtus pennsylvanicus*, 570; *M. pinetorum*, 7; *Microtus* (undetermined, but probably *pennsylvanicus*), 26; *Zapus hudsonius*, 3; *Peromyscus leucopus*, 5; *Mus musculus*, 1; *Blarina parva*, 10; *B. brevicauda*, 6, and *Scalops* (?), 1. Thus *Microtus pennsylvanicus* would appear to be the most abundant mouse, and *Blarina parva* the commonest shrew.

In conclusion, it may be noted that these data add further support to the well-proven results of ornithologists, that our local owls (with the possible exception of the great-horned owl) are of the greatest benefit to the agriculturist. Our three commonest local owls, the screech, long-eared, and short-eared (as well as the rarer acadian and barn owl), are indefatigable destroyers of mice and insects. But since this is the case, and since the group of the owls is one of great interest to the naturalist, it is to be hoped that future students of their dietary habits will avoid studying their stomachs for this purpose, and in order not to destroy them examine their food pellets instead.